

APPENDIX F

MODIFIED HABITAT PREFERENCE METHOD

RESULTS/DISCUSSION AND SUMMARY SHEETS

RED RIVER VALLEY WATER NEEDS ASSESSMENT

PHASE 1B

INSTREAM FLOW NEEDS ASSESSMENT

**MODIFIED HABITAT PREFERENCE METHOD
RESULTS/DISCUSSION AND SUMMARY SHEETS
USED IN THE AQUATIC LIFE MAINTENANCE FLOW ASSESSMENT**

Modified Habitat Preference Method

Methods available for assessing instream flows vary greatly in the issues they address, the uses for which they are intended, the assumptions underlying their application, and the intensity (and cost) of the effort required for the application. Considerable analysis and planning are required to tailor an instream flow analysis to meet the unique requirements of the resource, as well as applicable law and administrative procedures.

There are numerous instream flow methodologies which could have been used for the aquatic life maintenance flow needs assessment. Methodologies were grouped into "office" and "field/office" methods. Target species, planning schedules, and the amount of information deemed necessary to quantify the relationship between available fishery habitat and flow and to develop the seasonal instream flow regime were considered in ultimate method selection. The "field/office" approach which was utilized relied upon hydraulic simulation of flow at each study site transect (cross section) for each representative stream reach, with relationships developed between flows and certain hydraulic variables. Hydraulic variables, in turn, were related to fish habitat criteria.

Descriptive data were needed to display the effects of different flow regimes on resource values. Evaluative information was also needed to determine which set of conditions (e.g., instream fishery values and/or riverine riparian maintenance flows) were better or more desirable to evaluate resource conditions in terms of values (e.g., to decide what range of flows creates minimally acceptable, incremental, or optimal conditions). Once resource uses were established (e.g., fishery maintenance and spawning flows, riverine riparian corridor maintenance flows), the needed or desired resource conditions for providing those uses could be established. This required a study approach that recognized and thoroughly delineated resource values, while using appropriate methods to describe how flows related to resource conditions, and which applied evaluative standards to identify needed flows. Ultimately, study results will translate into the identification of the water costs where resource benefits would start to accrue, and the incremental levels of resource improvements for instream and riparian resources, for additional water costs (Phase II of the Red River Valley MR&I Water Needs Assessment).

The value-based process, which was utilized in this aquatic life maintenance flow needs assessment, consisted of five basic steps: (1) preliminary assessment and study design, (2) description of flow-dependent values, (3) description and quantification of hydrology and geomorphology, (4) description of the effects of flows on resource values, and (5) identification of instream flows to protect values. The value-based process is further discussed in Appendices A-F.

The quantification between available fishery habitat and flow and the development of the aquatic life maintenance seasonal instream flow regime were ultimately formulated to satisfy two distinct life stage periods of the fisheries year: the spawning and initial growth period (encompassing select species reproduction times), and the maintenance period (to satisfy fry survival and sustenance of juvenile and adult fish for the remainder of the year). The most critical period of the year for regulated and unregulated streams is the maintenance period (which corresponds to the low flow period) since flows are most susceptible to depletion due to drought and consumption during naturally dryer portions of the year and at times when off stream demands may be greatest (Brunson 1981).

Developing Representative Stream Reaches and Selection of Study Sites are addressed in Appendix A and this information will not be repeated here.

Selection of guild representatives for performing the Modified Habitat Preference Method assessment is discussed in Appendix D and this information will not be repeated here.

Performing hydraulic modeling of representative stream reaches is discussed in Appendix E and this information will not be repeated here.

Calculation of weighted usable area and quantification of the relationship between available fishery habitat and flow

Weighted usable area (WUA) within each representative stream reach and study site and each cross-sectional transect were calculated for each discharge of interest (see Appendix E for list of discharges used in the assessment) for each guild species. The WUA for each species within the guild was computed by integrating the products of depth and the preference curve value for depth and the mean column velocity and the preference curve value for velocity, across the representative cross section in a Lotus (Release 5) software spreadsheet. Combined habitat suitability was then multiplied by the amount of representative stream reach area which was measured at the specific study site and integrated over the representative reach to compute WUA. Available fishery habitat, expressed as percent of maximum WUA for all fish species versus flow was determined. This appendix contains summary sheets for each study site and species specific WUA by discharge and other quantitative relationship information.

Establishing an aquatic life maintenance seasonal instream flow regime utilizing the modified habitat preference method

As previously stated, a variation of the computational methods used by PHABSIM of the IFIM was developed and used to evaluate instream flow needs for the Modified Habitat Preference Method. The variation consisted of selecting representative stream reaches (and establishing and collecting representative cross-sectional data) on the Sheyenne River and the Red River of the North, performing hydraulic modeling (using the U.S. Army Corps of Engineers HEC-RAS

Model) to approximate velocity and depth distribution for site-specific data collected, and using habitat preference curves for fish species (developed for similar watersheds in Minnesota) from a variety of guilds as developed by Aadland et al. (1991), to calculate WUA for each representative stream reach in a Lotus (Release 5) software spreadsheet format. The Modified Habitat Preference Method was used to develop the seasonal instream flow regime by applying the technique of Bovee (1982) to WUA calculated by the multiplicative technique. Application of this technique to maintenance and spawning periods required identifying the minimum amount of habitat for all species over a range of discharges. This method consisted of optimizing the WUA for each species/life stage by the maximum WUA value.

Developing an aquatic life maintenance seasonal instream flow regime

In addition to utilizing the Modified Preference Method, a Goal Oriented Methodology was explored to help develop the seasonal instream flow regime as well as to provide an example for resource managers and for consideration in utilizing the seasonal instream flow regime for future planning and management purposes. For the Sheyenne River, the Goal Oriented Methodology was to maintain 50 percent of the WUA for all species during the maintenance period and maintain 50 percent of the WUA for all and/or select (target) species during the spawning period of the year (for the spawning period, selecting the flow which maintains the greatest amount of habitat for either all or target species, whichever was deemed to be reasonable based on professional judgement).

For the Red River of the North, the Goal Oriented Methodology was developed to consider two goals in developing the seasonal instream flow regime: (1) maintain 50 percent of the WUA in the stream during the maintenance and spawning periods of the year for all species, and (2) maintain 50 percent of the WUA in the stream during the spawning period of the year for all species (three options) plus maximize spawning WUA for channel catfish young (CCY) at 80 percent of available WUA (for the spawning period, selecting the flow which maintains the greatest amount of habitat for either all or select (target) species, whichever was deemed to be reasonable based on professional judgement).

Results and Discussion

Table F-1 displays both results of the Modified Habitat Preference Method (Multiplicative Technique) and the Goal Oriented Methodology. Tables F-2 contain site specific summary sheets used in the analysis. These summary sheets should be reviewed for additional information.

Results (instream flows) reported for the Modified Habitat Preference Method upstream and downstream of Lake Ashtabula are generally greater than those reported for Houston. In an attempt to determine what caused the differences in results, Houston Engineering, Inc., completed an analysis of hydraulic calculations used in both studies and reviewed the preference curves associated with the fish species used in the analyses.

First, Houston Engineering, Inc., compared the results of hydraulic calculations made at the Lisbon, North Dakota, study site (see Appendix E for details associated with this analysis). The velocity and depth, relative frequency and cumulative frequency distributions obtained from the GDCC study and the Reclamation study show considerable similarity. Although some differences are present between the relative frequency distributions, the cumulative frequency distributions “average out” the differences over the range of stream velocities and depths. When considering that the transects analyzed in each study represented different river reaches, the “averaged” results show that overall, the hydraulic analyses are quite similar.

As a result, the differences between the instream flow recommendations made in the GDCC study and the Reclamation aquatic life seasonal instream flow regime were deduced to not likely be associated with the hydraulic calculations, but rather the fish species selected for evaluation. Velocity and depth preference curves for both the spawning period and the non-spawning period (or maintenance period) of selected fish species were evaluated. Because the velocity and depth preference curves for a particular fish species changes according to the spawning and non-spawning periods, different fish species were selected to cover the possible range of habitats for these periods. The analysis showed that there was a gap in the non-spawning period, velocity and depth preference curves, for the species evaluated in the GDCC study. Since the hydraulic calculations of each study were shown to be similar, it is expected that this gap is responsible for the differences in instream flow results, and ultimately, instream flow regimes (see Appendix E).

Multiplicative technique flows generally result in more water and habitat (expressed as WUA) being maintained in the stream than most flows derived by applying the Goal Oriented Methodology (see Summary Tables which appear later).

As an example, at the Lisbon Study Site, Sheyenne River, multiplicative technique flows for all species would maintain 777135 WUA compared to 585300 WUA for the Goal Oriented Methodology (59 percent of the maximum available WUA versus 49 percent for the maintenance period and 59 versus 43 percent respectively, during the spawning period). For target species (or life stages), e.g., smallmouth bass fingerlings, walleye spawning, shorthead redhorse spawning, and channel catfish young, multiplicative technique flows would maintain 799612 WUA compared to 621028 WUA for the Goal Oriented Methodology (64 percent of the maximum available WUA versus 58 percent for the maintenance period and 68 versus 58 percent, respectively, during the spawning period).

The average depth and velocity of the stream at the Lisbon Study Site during the maintenance period (70 cfs flow for the multiplicative technique) was calculated to be 1.50 feet at 0.98 cfs. For spawning period flows (75 cfs for all species and 225 cfs for target species for the multiplicative technique), average depth and velocity was calculated to be 1.53 feet at 1.02 cfs and 2.13 feet at 1.90 cfs, respectively. Goal Oriented Methodology maintenance and spawning flows would result in less average depth and velocity at the site.

Table F-1. Summary of the Multiplicative Technique and Goal Oriented Methodology Results.

STUDY SITE	MULTIPLICATIVE TECHNIQUE					AQUATIC LIFE MAINTENANCE GOAL				
	Maintenance All Species	Spawning All Species	Spawning Select Species			Maintenance All Species	Spawning All Species	Spawning Select Species		
Warwick ¹	25	100	-			-	-	-		
Lisbon	70	75	225			25	35	70		
Ft. Ransom	70	125	340			55	340	125		
Pigeon Point	50	70	155			50	50	100		
Norman	130	100	150			50	100	100		
	Maintenance All Species	Spawning All Species	Spawning - All except WS, CCY	Spawning - Select except WS	Spawning - CCY	Maintenance All Species	Spawning All Species	Spawning - All except WS, CCY	Spawning - Select except WS	Spawning - CCY
Red River	100	125	133	125	75	50	375	450	450	450

¹Results displayed for Houston Engineering Inc., Study (1997)

The surface area of the study reach increases from 7,892 ft² (wetted perimeter surface area of 7,980 ft²) during maintenance flows to 7,927 ft² for all species and 8,728 ft² for target species, respectively, during spawning flows (see Summary Tables).

For the Red River of the North at Fargo, North Dakota, multiplicative technique flows for all species would maintain 117800980 WUA compared to 76960536 WUA for the Goal Oriented Methodology (51 percent of the maximum available WUA versus 47 (Goal # 1) or 49 percent (Goal # 2) for the maintenance period and 48 versus 65 (Goal # 1) and 70 (Goal # 2) percent, respectively, during the spawning period). For target species (or life stages), e.g., channel catfish young, multiplicative technique flows would maintain 117800980 WUA compared to 76960536 WUA for the Goal Oriented Methodology (35 percent of the maximum available WUA versus 80 percent for the maintenance period and 48 versus 70 percent, respectively, during the spawning period)(see Summary Tables).

The average depth and velocity of the stream at the Red River (Fargo) Study Site during the maintenance period (100 cfs flow for the multiplicative technique) was calculated to be 3.59 feet at 0.39 cfs. For spawning period flows (125 to 133 cfs for all species or variations of target species for the multiplicative technique), average depth and velocity was calculated to be 4.02 to 4.17 feet at 0.38 cfs, respectively. Goal Oriented Methodology maintenance flows (50 cfs) would result in less average depth but greater velocity at the site (2.47 feet at 0.41 cfs). Goal Oriented Methodology spawning flows (375 to 450 cfs) would result in greater average depth (7.17 to 7.87 feet) and velocity (0.43 cfs) at the site.

The surface area of the study reach increases from 55,356 ft² (wetted perimeter surface area of 56,358 ft²) during maintenance flows to 62,548 ft² for all species and 63,758 ft² for variations of target species, respectively, during spawning flows (see Summary Tables).

See Summary Tables for more comparative information related to the other study sites and results of applying the multiplicative technique and the Goal Oriented Methodology.

Aquatic Life Maintenance Seasonal Instream Flow Regime

The aquatic life maintenance seasonal instream flow regime was developed to provide an instream flow foundation for the current Red River Valley MR&I Water Needs Assessment. The rationale in completing this study was to provide sufficient analyses for the development of defensible recommendations for immediate planning purposes and to lay the foundation for additional future refinement. Reclamation believes that the aquatic life maintenance seasonal instream flow regime represents a flow regime which is capable of maintaining an acceptable level of instream values in the Sheyenne River and Red River of the North systems. An acceptable level of instream values was previously defined as those which would maintain the ecological integrity of the riverine ecosystem (maintaining the existing community structure at a defined level based on the application of hydrologic, hydraulic, and habitat based methodologies).

The data presented in Table 3 (Instream Flow Needs Assessment) demonstrate that the application of different methodologies will result in differing instream flow recommendations for any given location on the Sheyenne River and/or the Red River of the North. Use of the Modified Habitat Preference Method, both the multiplicative technique and the Goal Oriented Methodology (plus consideration of historic flows and hydrologic and hydraulic method results) resulted in the most defensible approach to developing an aquatic life maintenance seasonal instream flow regime for the study area for this appraisal level of analysis. Again, the aquatic life maintenance seasonal instream flow regime is presented in Table 3 and displayed in the “Reclamation” Aquatic Life Maintenance Seasonal Instream Flow Regime row of the table and also displayed in Table F-2 below.

Summary tables display comparisons between mean monthly flow rates and WUA for all species (and/or species life stages) and the developed aquatic life maintenance seasonal instream flow regime flow WUA for all species (and/or species life stages), for selected sites on the Sheyenne River and the Red River of the North. For the both the Sheyenne River and the Red River of the North, aquatic life maintenance seasonal instream flow regime flows would generally result in similar amounts of habitat being maintained for all sites considered (mean historic flows versus seasonal instream flows) but require less water (instream water) to produce the results.

For the Sheyenne River, an average of 61 percent of the maximum WUA for all species would be maintained during the maintenance period of the year and 66 percent of the maximum WUA for all species would be maintained during the spawning period of the year. For the Red River of the North, an average of 50 percent of the maximum WUA for all species would be maintained during the maintenance period of the year and 70 percent of the maximum WUA for all species would be maintained during the spawning period of the year.

On the Platte River in Nebraska, the U.S. Fish and Wildlife Service has developed a flow regime for fisheries which provided approximately 72 percent of the optimum physical habitat for all groups of fish analyzed [Biological Opinion for Kingsley Dam (FERC Project No. 1417) and North Platte/Keystone Diversion Dam (FERC Project No. 1835) Projects, Nebraska]. The aquatic life maintenance seasonal instream flow regime developed for this study compares favorably with the Platte River study (Sheyenne River - maintaining an average of 61 percent of the maximum WUA available for all species during the maintenance period of the year and 66 percent of the maximum WUA available for all species during the spawning period of the year; Red River of the North - an average of 70 percent of the maximum WUA available for all species would be maintained during the maintenance period of the year and 70 percent of the maximum WUA available for all species would be maintained for the spawning period of the year).

Table F-2
 Sheyenne River and Red River of the North
 Seasonal Instream Flow Regime for Aquatic Life Maintenance

Location	Flows in Cubic Feet Per Second (cfs)											
	Jan ¹	Feb	Mar ¹	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sheyenne River												
Harvey, ND	15	15	25	25	25	25	15	15	15	15	15	15
Warwick, ND ²	25	25	100	100	100	100	25	25	25	25	25	25
Cooperstown, ND	50	50	125	125	125	125	50	50	50	50	50	50
Baldhill Dam, ND	50	50	125	125	125	125	50	50	50	50	50	50
Valley City, ND	50	50	125	125	125	125	50	50	50	50	50	50
Lisbon, ND ²	70	70	225	225	225	225	70	70	70	70	70	70
Kindred, ND ²	50	50	155	155	155	155	50	50	50	50	50	50
West Fargo, ND ²	50	50	100	100	100	100	50	50	50	50	50	50
Harwood, ND	50	50	100	100	100	100	50	50	50	50	50	50
Red River of the North												
Wahpeton, ND	100	100	450	450	450	450	100	100	100	100	100	100
Hickson, ND	100	100	450	450	450	450	100	100	100	100	100	100
Fargo, ND ²	100	100	450	450	450	450	100	100	100	100	100	100
Halstad, MN	200	200	1125	1125	1125	1125	200	200	200	200	200	200
Grand Forks, ND	440	440	2160	2160	2160	2160	440	440	440	440	440	440
Drayton, ND	480	480	2610	2610	2610	2610	480	480	480	480	480	480
Emerson, Manitoba, Canada	520	520	3060	3060	3060	3060	520	520	520	520	520	520

¹Maintenance flows provided for the months of July-February; Spawning flows provided for the months of March-June.

²Actual data collection resulted in flow regime (either Reclamation or Houston Engineering, Inc. sites; all other site flow regimes based on estimated needs).

Literature Cited

Aadland, L.P., C.M. Cook, M.T. Negus, H.G. Drewes, and C.S. Anderson. 1991. Microhabitat preferences of selected stream fishes and a community-oriented approach to instream flow assessment. Minnesota Department of Natural Resources, Section of Fisheries, Investigational Report No. 406. 125 pp.

Bovee, K. 1982. A guide to stream habitat analysis using the instream flow incremental methodology. Instream Flow Information Paper No. 12. FWS/OBS-82/26. U.S. Fish and Wildlife Service, Office of Biological Services, Fort Collins, CO.

Stalnaker, C. B., B. Lamb, J. Henriksen, K. Bovee, and J. Bartholow. 1994. The Instream Flow Incremental Methodology: A Primer for IFIM. National Ecology Research Center, Internal Publication. National Biological Survey. Fort Collins, CO. 99 pp.

SUMMARY TABLES

Tables F-2

Specific Study Site Summary Sheets

Sheyenne River at Warwick Aquatic Life Maintenance Seasonal Instream Flow Regime.

														Houston Eng
	Mean Monthly	Multiplicative	Multiplicative	Goal	Goal	O'Shea Method	Houston Eng		Multiplicative	Multiplicative	Goal	Goal	O'Shea	Mod Hab Pref
	Period of	Technique	Technique	Methodology	Methodology	Recomm-	Mod Hab Pref	Mean Monthly	Technique	Technique	Methodology	Methodology	Method	Method
	Record	All Species	Target Species	All Species	Target Species	endations	Method Recomm	All Species	All Species	Target Species	All Species	Target Species	All Species	All Species
Month	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA
January	4	70	70	25	25	36	25	66715	79494	79494	60292	60292	66715	60292
February	27	70	70	25	25	43	25	69881	79494	79494	60292	60292	69881	60292
March	86	75	225	35	70	148	100	41327	35296	40915	25741	34673	40719	38413
April	266	75	225	35	70	413	100	32431	35296	40915	25741	34673	37648	38413
May	93	75	225	35	70	210	100	39564	35296	40915	25741	34673	41209	38413
June	51	75	225	35	70	129	100	41075	35296	40915	25741	34673	40468	38413
July	29	70	70	25	25	84	25	86084	79494	79494	60292	60292	82057	60292
August	12	70	70	25	25	36	25	66715	79494	79494	60292	60292	66715	60292
September	9	70	70	25	25	33	25	65069	79494	79494	60292	60292	65069	60292
October	10	70	70	25	25	36	25	66715	79494	79494	60292	60292	66715	60292
November	10	70	70	25	25	46	25	72142	79494	79494	60292	60292	71237	60292
December	6	70	70	25	25	40	25	68524	79494	79494	60292	60292	68524	60292
TOTALS								716242	777136	799612	585300	621028	716957	635988
AVERAGES	50	72	122	28	40	105	50							
									Multiplicative	Multiplicative	Goal	Goal		Houston Eng
								Mean Monthly	Technique	Technique	Methodology	Methodology	O'Shea Method	Mod Hab Pref
								% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg
								and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA
								for All Species	All Species	Target Species	All Species	Target Species	All Species	All Species
								Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn
								Period	Period	Period	Period	Period	Period	Period
								43/60	79/59	79/64	55/49	55/58	67/63	55/63
								40/61	62/59	62/68	47/43	47/58	55/67	47/64

Sheyenne River at Lisbon Aquatic Life Maintenance Seasonal Instream Flow Regime.

	Mean Monthly	Multiplicative	Multiplicative	Goal	Goal	O'Shea Method		Multiplicative	Multiplicative	Goal	Goal	O'Shea
	Period of	Technique	Technique	Methodology	Methodology	Recomm-	Mean Monthly	Technique	Technique	Methodology	Methodology	Method
	Record	All	Target Species	All Species	Target Species	endations	All Species	All Species	Target Species	All Species	Target Species	All Species
Month	Flow(cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA
January	36	70	70	25	25	36	66715	79494	79494	60292	60292	66715
February	43	70	70	25	25	43	69881	79494	79494	60292	60292	69881
March	204	75	225	35	70	148	41327	35296	40915	25741	34673	40719
April	609	75	225	35	70	413	32431	35296	40915	25741	34673	37648
May	298	75	225	35	70	210	39564	35296	40915	25741	34673	41209
June	175	75	225	35	70	129	41075	35296	40915	25741	34673	40468
July	106	70	70	25	25	84	86084	79494	79494	60292	60292	82057
August	36	70	70	25	25	36	66715	79494	79494	60292	60292	66715
September	33	70	70	25	25	33	65069	79494	79494	60292	60292	65069
October	36	70	70	25	25	36	66715	79494	79494	60292	60292	66715
November	48	70	70	25	25	46	72142	79494	79494	60292	60292	71237
December	40	70	70	25	25	40	68524	79494	79494	60292	60292	68524
TOTALS							716242	777136	799612	585300	621028	716957
AVERAGES	139	72	122	28	40	105						
								Multiplicative	Multiplicative	Goal	Goal	
							MeanMonthly	Technique	Technique	Methodology	Methodology	O'Shea Method
							% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg
							and	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA
							for	All Species	Target Species	All Species	Target Species	All Species
							Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn
							Period	Period	Period	Period	Period	Period
							67/61	79/59	79/64	55/49	55/58	67/63
							55/65	62/59	62/68	47/43	47/58	55/67

Sheyenne River at Kindred Aquatic Life Maintenance Seasonal Instream Flow Regime.

	MeanMonthly	Multiplicative	Multiplicative	Goal	Goal	O'Shea Method		Multiplicative	Multiplicative			
	Period of	Technique	Technique	Methodology	Methodology	Recomm-	Mean Monthly	Technique	Technique	Methodology	Methodology	Method
	Record	All	Target Species	All Species	Target Species	endations	All Species	All Species	Target Species	All Species	Target Species	All Species
Month	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA
January	48	50	50	50	50	47	73953	75781	75781	75781	75781	72953
February	55	50	50	50	50	51	79569	75781	75781	75781	75781	76539
March	206	70	155	50	100	150	57014	31115	56510	33239	47303	55736
April	658	70	155	50	100	445	40125	31115	56510	33239	47303	50651
May	392	70	155	50	100	272	54256	31115	56510	33239	47303	57854
June	241	70	155	50	100	172	57394	31115	56510	33239	47303	56734
July	171	50	50	50	50	127	83312	75781	75781	75781	75781	75836
August	73	50	50	50	50	63	87420	75781	75781	75781	75781	82781
September	57	50	50	50	50	52	80781	75781	75781	75781	75781	78781
October	57	50	50	50	50	52	80781	75781	75781	75781	75781	78781
November	68	50	50	50	50	60	88933	75781	75781	75781	75781	82000
December	55	50	50	50	50	51	78781	75781	75781	75781	75781	76781
TOTALS							862319	730708	832288	739204	795460	845427
AVERAGES	173	57	85	50	67	129						
								Multiplicative	Multiplicative	Goal	Goal	
							MeanMonthly	Technique	Technique	Methodology	Methodology	O'Shea Method
							% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg
							and	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA
							for	All Species	Target Species	All Species	Target Species	All Species
							Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn
							Period	Period	Period	Period	Period	Period
							60/50	55/53	55/53	55/53	55/53	60/55
							61/63	57/37	57/57	57/40	57/57	59/66

Sheyenne River at West Fargo Aquatic Life Maintenance Seasonal Instream Flow Regime.

	Mean Monthly	Multiplicative	Multiplicative	Goal	Goal	O'Shea Method		Multiplicative	Multiplicative	Goal	Goal	O'Shea
	Period of	Technique	Technique	Methodology	Methodology	Recomm-	Mean Monthly	Technique	Technique	Methodology	Methodology	Method
	Record	All	Target Species	All Species	Target Species	endations	All Species	All Species	Target Species	All Species	Target Species	All Species
Month	Flow(cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA
January	48	130	130	50	50	46	182932	116210	116210	202745	202745	163114
February	55	130	130	50	50	51	171135	116210	116210	202745	202745	196423
March	191	100	150	100	100	140	53891	47984	51716	47984	47984	50725
April	671	100	150	100	100	454	57933	47984	51716	47984	47984	57631
May	401	100	150	100	100	277	58018	47984	51716	47984	47984	56280
June	253	100	150	100	100	180	55433	47984	51716	47984	47984	53091
July	181	130	130	50	50	134	133618	116210	116210	202745	202745	121210
August	78	130	130	50	50	66	121017	116210	116210	202745	202745	76315
September	57	130	130	50	50	52	170135	116210	116210	202745	202745	194423
October	58	130	130	50	50	53	169135	116210	116210	202745	202745	196423
November	70	130	130	50	50	61	76315	116210	116210	202745	202745	139315
December	56	130	130	50	50	52	169135	116210	116210	202745	202745	194423
TOTALS							1418697	1121616	1136544	1813896	1813896	1499373
AVERAGES	177	120	137	67	67	131						
								Multiplicative	Multiplicative	Goal	Goal	
							MeanMonthly	Technique	Technique	Methodology	Methodology	O'Shea Method
							% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg
							and	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA
							for	All Species	Target Species	All Species	Target Species	All Species
							Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn
							Period	Period	Period	Period	Period	Period
							50/72	56/65	56/74	54/65	54/65	46/73
							58/89	45/76	45/82	79/76	79/76	66/87

Red River of the North at Fargo Aquatic Life Maintenance Seasonal Instream Flow Regime.

	Mean		Multiplicative					Goal			Combination	O' Shea			Multiplicative					Goal			Combination	
	Monthly	Multiplicative	Technique	Multiplicative	Multiplicative	Goal # 1	Goal # 2	Methodology	Goal	Goal	Methodology	Method	Mean	Multiplicative	Technique	Multiplicative	Multiplicative	Goal # 1	Goal # 2	Methodology	Goal	Goal	Methodology	O' Shea
	Period	Technique	All Species	Technique	Technique	Methodology	Methodology	All Species	Methodology	Methodology	All Species	Recomm-	Monthly	Technique	All Species	Technique	Technique	Methodology	Methodology	All Species	Methodology	Methodology	All Species	Method
	Record	All		All Sp - WS	CCY	All Species	All Species	- WS	CCY	All Sp - WS	CCY	& CCY Methodology	All Species	All Species	- WS, CCY	All Sp - WS	CCY	All Species	All Species	- WS, CCY	All Sp - WS	CCY	& CCY Max	All Species
Month	Flow	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA	Flow WUA
January	198	100	100	100	100	50	50	50	50	50	100	135	1475233	14622892	14622892	14622892	14622892	9472609	9472609	9472609	9472609	9472609	14622892	1213372
February	202	100	100	100	100	50	50	50	50	50	100	137	1491625	14622892	14622892	14622892	14622892	9472609	9472609	9472609	9472609	9472609	14622892	1223372
March	598	125	125	133	125	375	450	450	450	450	450	407	327508	204461	204461	216884	204461	273714	294916	294916	294916	294916	294916	280781
April	1810	125	125	133	125	375	450	450	450	450	450	1202	388906	204461	204461	216884	204461	273714	294916	294916	294916	294916	294916	388906
May	1014	125	125	133	125	375	450	450	450	450	450	680	388906	204461	204461	216884	204461	273714	294916	294916	294916	294916	294916	341877
June	1059	125	125	133	125	375	450	450	450	450	450	709	388906	204461	204461	216884	204461	273714	294916	294916	294916	294916	294916	346566
July	814	100	100	100	100	50	50	50	50	50	100	509	25300566	14622892	14622892	14622892	14622892	9472609	9472609	9472609	9472609	9472609	14622892	24772560
August	339	100	100	100	100	50	50	50	50	50	100	220	2033756	14622892	14622892	14622892	14622892	9472609	9472609	9472609	9472609	9472609	14622892	1523598
September	227	100	100	100	100	50	50	50	50	50	100	152	1583938	14622892	14622892	14622892	14622892	9472609	9472609	9472609	9472609	9472609	14622892	1294474
October	240	100	100	100	100	50	50	50	50	50	100	160	1664278	14622892	14622892	14622892	14622892	9472609	9472609	9472609	9472609	9472609	14622892	1324474
November	233	100	100	100	100	50	50	50	50	50	100	155	1603938	14622892	14622892	14622892	14622892	9472609	9472609	9472609	9472609	9472609	14622892	1304474
December	204	100	100	100	100	50	50	50	50	50	100	138	1483598	14622892	14622892	14622892	14622892	9472609	9472609	9472609	9472609	9472609	14622892	1233372
TOTALS													38131158	117800980	117800980	117850672	117800980	76875728	76960536	76960536	76960536	76960536	118162800	35247826
AVERAGES	578	108	108	111	108	158	183	183	183	183	217	384												
																							Combination	
														Multiplicative	Multiplicative	Multiplicative	Multiplicative	Goal # 1	Goal # 2	Goal	Goal	Goal	Methodology	
													Mean	Technique	Technique	Technique	Technique	Methodology	Methodology	Methodology	Methodology	Methodology	All Sp & CCY Max	O'Shea Method
													% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg	% WUA Avg
													and	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA	and % Max WUA
													for	All Species	All Sp - WS, CCY	All Sp - WS	CCY	All Species	All Species	All Sp - WS, CCY	All Sp - WS	CCY	CCY	All Species
													Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn	Maint/Spawn
													Period	Period	Period	Period	Period	Period	Period	Period	Period	Period	Period	Period
													58/61	62/51	62/61	62/73	62/35	54/47	54/49	54/52	54/71	54/80	62/80	59/58
													16/87	50/48	50/48	50/51	50/48	32/65	32/70	32/70	32/70	32/70	50/70	5/81

Sheyenne River and Red River of the North Modified Habitat Preference Method and Aquatic Life Maintenance Seasonal Instream Flow Regime.

		05054500 Sheyenne River above Harvey, ND 1931-1984		05056000 Sheyenne River near Warwick, ND 1931-1984		05057000 Sheyenne River near Cooperstown, ND 1931-1984	
Modified Habitat Preference Method	Reclamation	Mar-Jun _* 25**	Jul-Feb _* 15**	Mar-Jun 75 (all sp), 225(target sp)* 35 (all sp), 70 (target sp)**	Jul-Feb 70 (all sp)* 25 (all sp)**	Mar-Jun 75 (all sp), 225(target sp)* 35 (all sp), 70 (target sp)**	Jul-Feb 70 (all sp)* 25 (all sp)**
	Houston	Mar-Apr 100	May-Feb 25	Mar-Apr 100	May-Feb 25	Mar-Apr 100	May-Feb 25
Aquatic Life Maintenance Seasonal Instream Flow Regime	Reclamation	Mar-Jun 25	Jul-Feb 15	Mar-Jun 100	Jul-Feb 25	Mar-Jun 125	Jul-Feb 50
	Houston	Mar-Apr 6	May-Feb 2	Mar-Apr 50	May-Feb 25	Mar-Apr 71	May-Feb 25

		05058000 Sheyenne River below Baldhill Dam, ND 1931-1984		05058500 Sheyenne River at Valley City, ND 1931-1984		05058700 Sheyenne River at Lisbon, ND 1931-1984	
Modified Habitat Preference Method	Reclamation	Mar-Jun 340 (all sp), 125 (target sp)* 125 (all sp), 340 (target sp)**	Jul-Feb 70 (all sp)* 55 (all sp)**	Mar-Jun 340 (all sp), 125 (target sp)* 125 (all sp), 340 (target sp)**	Jul-Feb 70 (all sp)* 55 (all sp)**	Mar-Jun 75 (all sp), 225 (target sp)* 35 (all sp), 70 (target sp)**	Jul-Feb 70 (all sp)* 25 (all sp)**
	Houston	Mar-Apr 250	May-Feb 75	Mar-Apr 250	May-Feb 75	Mar-Apr 250	May-Feb 75
Aquatic Life Maintenance Seasonal Instream Flow Regime	Reclamation	Mar-Jun 125	Jul-Feb 50	Mar-Jun 125	Jul-Feb 50	Mar-Jun 225	Jul-Feb 70
	Houston	Mar-Apr 74	May-Feb 25	Mar-Apr 74	May-Feb 25	Mar-Apr 185	May-Feb 55

Sheyenne River and Red River of the North Modified Habitat Preference Method and Aquatic Life Maintenance Seasonal Instream Flow Regime (Cont').

		05059000 Sheyenne River near Kindred, ND 1931-1984		05059500 Sheyenne River at West Fargo, ND 1931-1984		05060400 Sheyenne River at Harwood, ND 1931-1984	
Modified Habitat Preference Method	Reclamation	Mar-Jun 70 (all sp), 155 (target sp)* 50 (all sp), 100 (target sp)**	Jul-Feb 50 (all sp)* 50 (all sp)**	Mar-Jun 100 (all sp), 150 (target sp)* 100 (all sp), 100 (target sp)*	Jul-Feb 130 (all sp)* 50 (all sp)**	Mar-Jun 100 (all sp), 150 (target sp)* 100 (all sp), 100 (target sp)*	Jul-Feb 130 (all sp)* 50 (all sp)**
	Houston	Mar-Apr 38	May-Feb 15	Mar-Apr 50	May-Feb 25	Mar-Apr 50	May-Feb 25
Aquatic Life Maintenance Seasonal Instream Flow Regime	Reclamation	Mar-Jun 155	Jul-Feb 50	Mar-Jun 100	Jul-Feb 50	Mar-Jun 100	Jul-Feb 50
	Houston	Mar-Apr 135	May-Feb 45	Mar-Apr 135	May-Feb 45	Mar-Apr 135	May-Feb 45

		05051500 Red River of the North at Wahpeton, ND 1942-1984		05051522 Red River of the North at Hickson, ND 1976-1984	
Modified Habitat Preference Method	Reclamation	Mar-Jun _* 450**	Jul-Feb _* 100***	Mar-Jun _* 450**	Jul-Feb _* 100***
	Houston	None	None	None	None
Aquatic Life Maintenance Seasonal Instream Flow Regime	Reclamation	Mar-Jun 450	Jul-Feb 100	Mar-Jun 450	Jul-Feb 100
	Houston	None	None	None	None

Sheyenne River and Red River of the North Modified Habitat Preference Method and Aquatic Life Maintenance Seasonal Instream Flow Regime (Cont').

		05054000 Red River of the North at Fargo, ND 1931-1984		05064500 Red River of the North at Halstad, MN 1931-1984	
Modified Habitat Preference Method	Reclamation	Mar-Jun 75-133 (various sp)** 450 (various sp)***	Jul-Feb 100 (all sp)* 50 (all sp)**	Mar-Jun _* 1125**	Jul-Feb _* 200***
	Houston	Mar-Apr 200	May-Feb 200	None	None
Aquatic Life Maintenance Seasonal Instream Flow Regime	Reclamation	Mar-Jun 450	Jul-Feb 100	Mar-Jun 1125	Jul-Feb 200
	Houston	Mar-Apr 200	May-Feb 200	None	None

		05082500 Red River of the North at Grand Forks, ND 1931-1984		05092000 Red River of the North at Drayton, ND 1931- 1984		05102500 Red River of the North at Emerson, Manitoba, Canada 1931-1984	
Modified Habitat Preference Method	Reclamation	Mar-Jun _* 2160**	Jul-Feb _* 440***	Mar-Jun _* 2610**	Jul-Feb _* 480***	Mar-Jun _* 3060**	Jul-Feb _* 520***
	Houston	None	None	None	None	None	None
Aquatic Life Maintenance Seasonal Instream Flow Regime	Reclamation	Mar-Jun 2160	Jul-Feb 440	Mar-Jun 2610	Jul-Feb 480	Mar-Jun 3060	Jul-Feb 520
	Houston	None	None	None	None	None	None

*Multiplicative Technique Results for all species (all sp) and target species (target sp).

**Maintaining approximately 50% of the Weighted Usable Area (WUA) available in the stream for both all species (all sp) and target species (target sp).

***Maintaining approximately 50% of the Weighted Usable Area (WUA) available in the stream for various target species and approximately 80% of the available habitat for channel catfish young (CCY).